Coyote responses to visual and olfactory stimuli related to familiarity with an area

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Abstract: Individual coyotes (*Canis latrans*) are infrequently captured within their familiar areas of activity. Current hypotheses are that the differential capture vulnerability may involve neophobia or inattentiveness. To assess the effect of familiarity, I measured coyote responsiveness to sensory cues encountered in familiar and novel settings. Seventy-four captive coyotes were presented with visual and olfactory stimuli in familiar and unfamiliar 1-ha enclosures. The visual stimuli were black or white wooden cubes of three sizes (4, 8, and 16 cm per side). The olfactory stimuli were fatty acid scent, W-U lure (trimethylammonium decanoate plus sulfide additives), and coyote urine and liquefied feces. Overall, coyotes were more responsive to stimuli during exploration in unfamiliar than in familiar enclosures. None of 38 coyotes that responded were neophobic toward the olfactory stimuli. The frequency of coyote response, and the resulting degrees of neophobia, did not differ between the black and white visual stimuli. Regardless of context, the largest visual stimuli were recognized at the greatest distance and evoked the strongest neophobic response. A greater proportion of coyotes were neophobic toward the small and medium-sized stimuli in familiar than in unfamiliar enclosures. This study demonstrated that when encountered in familiar environments, visual cues are more likely to elicit neophobic responses by coyotes than are olfactory stimuli.

Résumé : Des Coyotes (*Canis latrans*) sont parfois capturés au milieu même de leurs aires d'activité. Les hypothèses généralement considérées sont que cette vulnérabilité est attribuable à la néophobie ou à l'inattention. Pour évaluer l'effet de la familiarité, j'ai mesuré les réactions des coyotes à des signaux sensoriels rencontrés dans des milieux familiers et des milieux inconnus. Soixante-quatorze coyotes en captivité ont été mis en présence de stimulus visuels et olfactifs dans des enceintes de 1 ha connues et inconnues. Les stimulus visuels étaient des cubes de bois blancs ou noirs, de trois tailles (côté de 4, 9 ou 16 cm). Les stimulus olfactifs consistaient en une odeur à base d'acide gras, un leurre spécialisé, de l'urine de coyote et des fèces liquéfiées de coyote. Dans l'ensemble, les coyotes réagissaient plus aux stimulus durant l'exploration des enceintes inconnues. Aucun des 38 coyotes qui ont réagi n'a manifesté de la néophobie pour les stimulus olfactifs. La fréquence des réactions, et l'importance de la néophobie résultante, ne différait pas selon la couleur des stimulus visuels. En dépit du contexte, les stimulus les plus gros étaient perçus aux plus grandes distances et provoquaient les néophobies les plus fortes. Un plus grande proportion des coyotes se sont avérés néophobes à l'égard des stimulus de petite ou de moyenne taille dans les enceintes connues que dans les enceintes inconnues. Les résultats de l'étude démontrent qu'en milieu familier les stimulus visuels sont plus susceptibles de déclencher une réaction de néophobie que les stimulus olfactifs.
[Traduit par la Rédaction]

Introduction

Studies with radio-collared coyotes consistently show that individuals are relatively invulnerable to capture within their ranges. This phenomenon, documented in Oklahoma (Litvaitis 1975), Utah (Hibler 1977), Nebraska (Althoff 1978), Idaho (Woodruff and Keller 1982), Texas (Windberg and Knowlton 1990), and New Mexico (L.A. Windberg, unpublished data), involves both territorial and transient coyotes (Windberg and Knowlton 1990; L.A. Windberg, unpublished data). Lehner et al. (1976) noted that captive coyotes exhibited neophobic responses to various novel chemical odors placed in their familiar enclosures. Harris (1983) demonstrated that captive coyotes readily investigated novel stimuli encountered in unfamiliar enclosures, but were neophobic toward similar stimuli after the enclosure became familiar. Wild coyotes may similarly avoid some attractants used for capture in their familiar areas of activity. Based on observations of tracks, Griffith (1976) reported that some coyotes avoided scent stations used to estimate relative abundance. Variability in responses of coyotes to stimuli may affect (*i*) efficacy in targeting individuals for management purposes, (*ii*) the representativeness of population samples, and (*iii*) the validity of techniques used to estimate abundance.

Traditionally, coyotes are captured using olfactory attractants. Lures used with capture devices generally rely on the food-seeking, curiosity, or social behaviors of coyotes to elicit attraction. Studies that evaluated olfactory attractants (Fagre et al. 1983; Turkowski et al. 1983; Windberg and Knowlton 1990) failed to consider the ramifications of the setting in which coyotes encounter the stimuli. The behavioral responses of animals to novel stimuli involve the combined effect of attraction and aversion (Montgomery 1955), which appears to be influenced by their familiarity with the site where the stimuli are encountered (Harris 1983).

Although coyotes possess a keen olfactory sense, they

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rely heavily on visual cues in seeking prey (Wells 1978). The effect of visual stimuli has been generally ignored in comparisons of the attractiveness of lures (Roughton and Sweeny 1982; Fagre et al. 1983; Turkowski et al. 1983). Yet many coyote-capture devices (bait, snare, trap-set, cyanide ejector) have a visual component, albeit usually small. Furthermore, some trappers intentionally use visual cues, such as stones, bones, holes, and prominent plants or other natural features, in conjunction with trap-sets (Turkowski et al. 1983). The potential neophobic, repellent effect of visual stimuli on coyotes (Harris 1983) has not been thoroughly evaluated.

I tested captive coyotes in familiar and unfamiliar enclosures to determine the occurrence of neophobia in response to selected visual and olfactory stimuli. My objectives were to determine (*i*) if the behavioral responses of captive coyotes to olfactory stimuli differed between familiar and unfamiliar enclosures, as Harris (1983) observed for novel visual stimuli; and (*ii*) if the response was influenced by either the size or the color shade of visual stimuli in familiar or unfamiliar enclosures.

Methods

Visual stimuli

The 6 visual stimuli tested were solid wooden cubes, painted black or white, which were of three sizes: small (64 cm^3; 4 cm/side), medium (512 cm^3; 8 cm/side), or large (4096 cm^3; 16 cm/side). The smallest cube was comparable in size to the "coyote lure operative device" of Ebbert and Fagre (1987). The largest cube was comparable in size to the cubes and pyramids (15 cm/side) used by Harris (1983). The color shades represented extreme contrasts in light intensity and provided a strong contrast with the background. Wooden cubes were painted ≥ 7 days before exposure to the coyotes. To reduce odor, the cubes were washed in water and sodium bicarbonate and aired outdoors for ≥ 1 day before each test.

Olfactory stimuli

I tested two categories of olfactory stimuli: (1) synthetic coyote lures (FAS (fatty acid scent) and W-U lure (trimethylammonium decanoate plus sulfide additives)) and (2) coyote communication odors (coyote urine and feces). FAS is a standard attractant for predator abundance surveys (Bean 1981), and received a high response rate by coyotes in comparison with other olfactory attractants during previous tests (Roughton and Sweeny 1982; Phillips et al. 1990). W-U lure is a synthetic mixture composed of key attractants found in coyote urine and anal sacs and in fetid meat (Fagre et al. 1983), and it also received high rates of investigatory responses by captive (Fagre et al. 1983; Phillips et al. 1990) and wild coyotes (Ebbert and Fagre 1987). FAS and W-U lure were supplied by the Pocatello Supply Depot (U.S. Department of Agriculture, Pocatello, Idaho).

Scent marking with urine and feces is an important form of olfactory communication among canids (Kleiman and Brady 1978; Macdonald 1980; Gorman and Trowbridge 1989), eliciting stereotypic behavioral responses from conspecifics. For this study, I used urine and feces collected from captive coyotes that were not test subjects. To minimize the visual component, feces were liquefied by mixing with distilled water. Urine and feces were collected prior to the study, stored frozen in 3-mL aliquots, and thawed immediately before placement in the experimental enclosure. Three millilitres of coyote urine or liquefied feces and 0.5mL of FAS or W-U lure (as recommended by Ebbert and Fagre 1987) were used per test. Thus, each type of olfactory stimulus used throughout the study was from the same source and of equal quantity.

Experimental arena

Four adjoining wedge-shaped 1-ha enclosures at the Millville Predator Research Facility (MPRF) located 12 km south of Logan, Utah, served as experimental arenas. Each enclosure extended outward 160 m from a central elevated observation building to an outer 125-m arc. Vegetative cover in the enclosures consisted of native grasses mown 10–15 cm above ground level to enhance the visibility of the visual stimuli. Kennels under the observation building housed experimental coyotes during pretest periods. A wooden wall prevented coyotes in the kennels from viewing activities in the enclosures. Unnatural objects, which I perceived as competing novel visual stimuli for coyotes, were removed from the enclosures. The visual and olfactory stimuli were removed immediately after each test.

Experimental procedures

Captive coyotes (n = 74) from the MPRF served as experimental subjects. All coyotes were ≥ 1 year old and each was tested only once. Animals were exposed equally to the different categories of experimental stimuli according to their age, sex, and rearing and research history in order to reduce potential variability related to these factors. One to 3 days before testing, coyotes were transported from the main kennels at MPRF to kennels adjoining the test enclosures. Animal-use procedures were approved by the Institutional Animal Care and Use Committee of the Denver Wildlife Research Center, and were in accordance with the principles and guidelines of the Canadian Council on Animal Care.

Visual and olfactory stimuli were positioned in enclosures 13–18 h before each test. Only 1 visual stimulus was used per enclosure for the first 14 tests; subsequently, 2 of the same stimulus were used, to increase the probability of response. One olfactory stimulus was used per test. All stimuli were randomly placed on the ground 3 m perpendicular to the partition fences of the enclosures. Polyethylene gloves and boots were worn during placement of stimuli to minimize extraneous odors.

Coyotes tested in unfamiliar enclosures were released and observed until there was 1 interaction with each stimulus, or for 2 h. Coyotes tested in familiar enclosures were permitted to occupy the enclosure for 5 days. They were then confined to the kennel for 18–24 h while the stimuli were placed in their enclosure. During the next day, coyotes were released into their respective enclosures and observed until each stimulus was contacted at least once, or for 2 h.

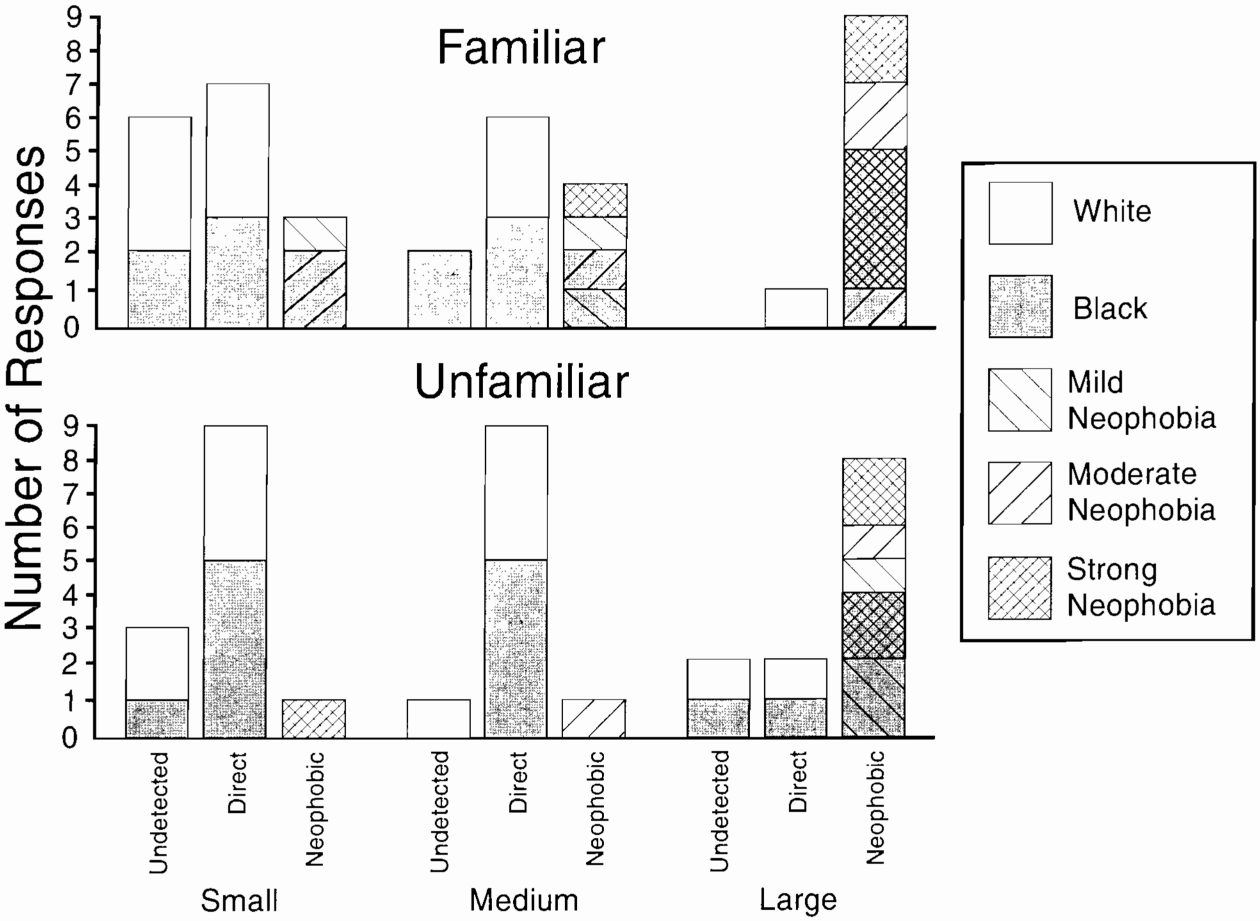
To confirm that 5 days of exposure were adequate to ensure familiarity, I quantified daily spatial use of the enclosures by 2 coyotes in a prestudy trial (L.A. Windberg, unpublished data). Both coyotes thoroughly explored the enclosure for the first 3 days and both occupied only a small portion of the enclosure space during the subsequent 6 days.

Measurement of behavioral response

Stimulus orientation was defined as an observable movement by the coyote toward a test cue. The subsequent responses were classified as follows: (*i*) direct: defined as an unhesitating approach and contact; (*ii*) mildly neophobic: defined as a deliberate but relatively quick (≤ 10 s) approach, with tense body posture; (*iii*) moderately neophobic: defined as a relatively slower (10–30 s) approach that included circling and (or) 1 or 2 retreats from the stimulus; and (*iv*) strongly neophobic: defined as a prolonged (≥ 30 s) approach that included circling, >2 retreats, and (or) orientation toward the stimulus from ≥ 1 m, or failure to approach within 1 m of the stimulus after orientation. When coyotes oriented away from a stimulus, the interaction was regarded as ended. If a coyote oriented toward a test stimulus again after the initial response, subsequent interactions were also classified. Interactions of coyotes with stimuli were videotaped and narrative descriptions were recorded.

Based on the relative time and intensity of exploration and spatial

Fig. 1. Distribution of 74 coyote responses to six types of visual stimuli in familiar and unfamiliar enclosures.



coverage of the enclosure during the test, the exploratory activity of each coyote was rated as none, little, moderate, or great. When possible, I estimated the distance from a stimulus at which a coyote's orienting response began, using the body length of the animal as the measure.

Data analysis

Fisher's exact test was used to analyze frequencies of responses to visual and olfactory stimuli as well as relative exploratory activity. The distances at which responses to visual stimuli occurred were analyzed by three-factor analysis of variance using the General Linear Model for unbalanced samples (SAS Institute Inc. 1988); differences among means were isolated with Duncan's multiple-range test. Response distances between olfactory stimuli and olfactory versus visual stimuli were compared by *t* test.

Results

Seventy-four captive coyotes were tested from 24 June to 28 September 1993. They included 37 males and 37 females. The age distribution of the coyotes was as follows: 18 were 1 year old, 5 were 2 years old, 17 were 3 years old, and 34 were ≥4 years old. Fifteen coyotes had been reared by humans and 59 by parental captives at MPRF. Fifty-five coyotes had no previous experience in the test enclosures, 12 coyotes had experience >1 year before the test, and 7 had previous experience within 4–10 months. My examination of the data for responses of coyotes to the various categories of visual and olfactory stimuli revealed no notable differences related to the age, sex, rearing history, or enclosure experience categories described above. I managed the experimental design to accumulate five behavioral responses to the 12 categories of visual stimuli (Fig. 1). There were 38 responses by coyotes to the 4 olfactory stimuli (Fig. 2).

The general exploratory pattern of coyotes involved walking around the perimeter of enclosures. In unfamiliar enclosures, 74% of 35 coyotes exhibited "great" exploratory activity during the test compared with only 19% of 31 coyotes in familiar enclosures ($\chi^2 = 19.8$, df = 1, $P < 0.001$).

Visual stimuli

Shade

There were no differences in the proportions of coyote orientation responses to black versus white visual stimuli among the three sizes ($\chi^2 \leq 0.7$, df = 1, $P \geq 0.40$), or in the proportion of coyotes making neophobic approaches to black versus white stimuli ($\chi^2 \leq 0.4$, df = 1, $P \geq 0.54$) (Fig. 1). Shades were therefore combined for subsequent analyses.

Size

In familiar enclosures, small visual stimuli (62%) elicited fewer ($\chi^2 = 4.5$, df = 1, $P = 0.05$) orientation responses than medium-sized and large stimuli (91%) (Fig. 1). In unfamiliar enclosures, there was no difference ($\chi^2 = 0.6$, df = 1, $P = 0.65$) in orientation responses to small (77%) versus medium-sized and large (87%) stimuli.

Fig. 2. Distribution of 38 coyote responses to 4 olfactory stimuli in familiar and unfamiliar enclosures.

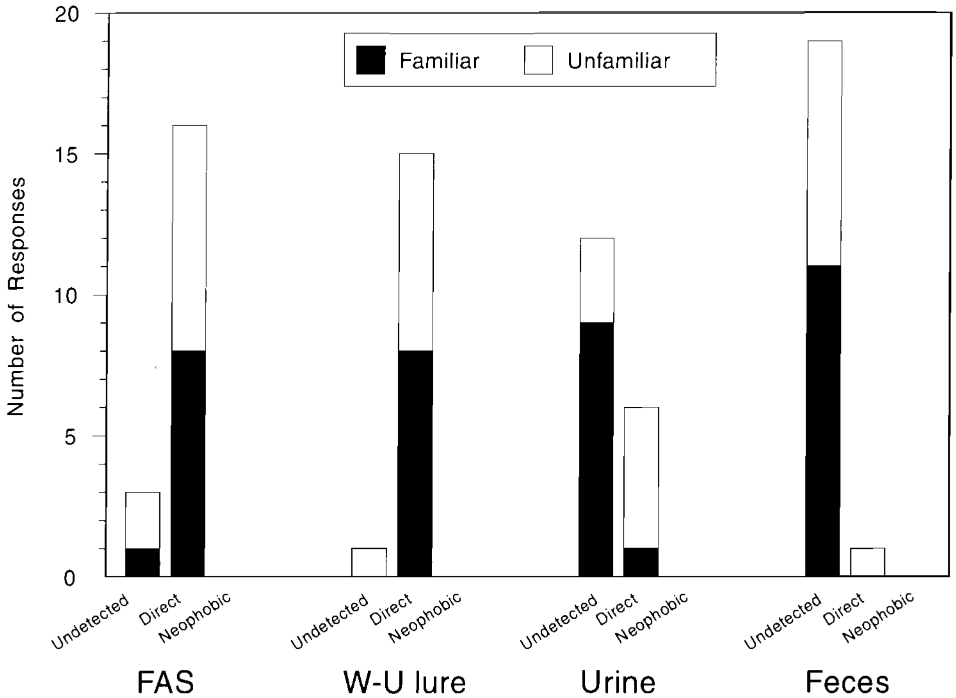


Table 1. Mean distances (m) at which captive coyotes responded to six visual stimuli in familiar and unfamiliar enclosures.

Visual stimulus	Familiar enclosure $\bar{x}$	SE	n	Unfamiliar enclosure $\bar{x}$	SE	n
Small						
Black	1.8	0.5	4	1.9	0.3	5
White	1.6	0.3	7	2.2	0.8	5
Medium						
Black	2.6	0.6	5	3.8	1.3	6
White	2.8	0.7	5	2.8	0.6	4
Large						
Black	4.7	1.1	7	3.1	0.3	7
White	4.4	0.9	7	3.4	0.4	7

The proportion of total neophobic responses (mild, moderate, strong) by coyotes varied among the three sizes of visual stimuli in both familiar (χ^2 = 8.3, df = 2, P = 0.02) and unfamiliar (χ^2 = 14.7, df = 2, P < 0.001) enclosures, with markedly greater neophobia toward the largest stimuli (Fig. 1). Although the difference was not statistically significant, responses classified as strongly neophobic tended to occur more frequently (χ^2 = 3.2, df = 1, P = 0.11) toward large stimuli than toward the small and medium-sized stimuli combined (Fig. 1). Seven of 12 coyotes that responded with strong neophobia did not approach <1 m of the stimulus.

Familiarity

There was a trend for neophobia to be stronger by coyotes toward all sizes of visual stimuli in familiar than in unfamiliar enclosures (Fig. 1). But the trend was only significant when responses to the small and medium-sized stimuli were combined (χ^2 = 3.6, df = 1, P = 0.06).

Response distance

There were no interactions ($F_{[11,57]}$ ≤1.9, P ≥ 0.15) between the mean distance of response and the shade or size of stimulus or familiarity with the enclosure (Table 1). The mean distance of response was greater ($F_{[2,57]}$ = 6.6, P < 0.01) for the large stimuli (4.6 m) than for the small (1.7 m) and medium-sized (2.7 m) stimuli.

Secondary response

I observed 24 secondary responses by coyotes to a visual stimulus, i.e., either a second investigation of the same stimulus or a response to the other stimulus of the same type. For 9 coyotes, no neophobia was detected during either the first or second interaction. For 9 coyotes in which strong neophobia had been previously observed, the secondary response was also strong neophobia for 5 individuals and either moderate (n = 3) or mild neophobia for the others. For 6 coyotes where the first response was mild or moderate neophobia, the secondary responses gave no indication of neophobia for 5 individuals and only mild neophobia for the other.

Olfactory stimuli

I observed no neophobic responses by coyotes (n = 38) to any of the 4 olfactory stimuli in either the familiar or unfamiliar enclosures (Fig. 2). The frequencies of coyote responses to FAS and W-U lure in both familiar (94%) and unfamiliar (83%) enclosures were greater (χ^2 = 13.2, df = 3, P < 0.01) than those of responses to coyote urine (33%) and feces (5%) (Fig. 2). All 15 coyotes that investigated W-U lure, and 13 of 16 that investigated FAS, engaged in "rub-rolling" behavior (Phillips et al. 1990) for lengthy periods ($\geq$30 s) at the attractant site. Only 1 of 20 coyotes was observed to respond to the odor of liquefied coyote feces in familiar and unfamiliar enclosures (Fig. 2). The percentage of coyotes (n = 8) observed responding to urine in unfamiliar enclosures was greater than the percentage of coyotes (n = 10) in familiar enclosures (63 vs. 10%) (χ^2 = 5.5, df = 1, P = 0.04).

There were no differences (t = 0.8, df = 24, P = 0.46) in the mean distances at which coyotes were observed to respond to FAS ($\bar{x}$ = 2.3 m, SE = 0.4 m, n = 14) versus W-U lure ($\bar{x}$ = 1.9 m, SE = 0.3 m, n = 12) or to FAS and W-U lure versus coyote urine and feces ($\bar{x}$ = 1.5 m, SE = 0.2 m, n = 5) (t = 1.0, df = 29, P = 0.35). The observed response distance for all 4 olfactory stimuli ($\bar{x}$ = 2.0 m, SE = 0.2 m) did not differ (t = 0.4, df = 50, P > 0.50) from the distance for small ($\bar{x}$ = 1.9 m, SE = 0.2 m) visual stimuli, but was less than that for both the medium-sized ($\bar{x}$ = 3.0 m, SE = 0.5 m) (t = 2.2, df = 49, P = 0.04) and large ($\bar{x}$ = 3.9 m, SE = 0.4 m) (t = 4.2, df = 57, P < 0.001) visual stimuli.

Discussion

In experiments with captive coyotes, Harris (1983) demonstrated that they exhibit neophobic behavior toward novel stimuli, and showed that neophobic responses occur most frequently in familiar environments. The decrease in visitation rates by coyotes to scent stations on study areas subjected to intensive capture–release trapping with the use of olfactory attractants (Andelt et al. 1985; F.F. Knowlton and L.A. Windberg, unpublished data) suggests that some individuals may have learned to avoid odors associated with trap-sets. Linhart et al. (1976) found that captive coyotes exhibited rapid acquisition and long retention (3–9 months) of an avoidance response to a noxious stimulus (electric shock). The relatively low vulnerability of wild coyotes to capture in their ranges (Hibler 1977; Woodruff and Keller 1982; Windberg and Knowlton 1990) suggests that they either avoid some feature of the capture technique or their attentiveness varies according to their familiarity with an area.

In controlled experiments, Wells and Lehner (1978) rated vision, audition, and olfaction as the order of relative importance of these three senses to coyotes for locating prey (rabbits). They suggested that reliance on vision has evolved in coyotes so that they can operate at night. But based on observations of the feeding behavior of captives, Österholm (1964) concluded that in foxes (*Vulpes vulpes*) the use of vision diminishes with decreasing illumination. Because my study was conducted during daylight, the results may not be applicable under conditions of darkness.

Overall, I found no differences in coyote responses to black and white visual stimuli with regard to orientation or neophobia. In a field test, Roughton and Sweeny (1982) reported no difference in visitation rates of coyotes to scent stations where the olfactory attractant (FAS) was presented with a white stimulus versus no visual stimuli.

Because there were no neophobic approaches to any olfactory stimuli during this study, I infer that neophobia by coyotes toward novel stimuli may be associated primarily with visual rather than olfactory properties of a stimulus. I found that although some individuals exhibited neophobia toward the 2 smallest visual stimuli used in the tests, a preponderance of coyotes showed initial neophobic responses to the largest stimuli. The gradient of responses to the three sizes of visual stimuli tested indicated that the largest was recognized at a greater distance by coyotes and also evoked the strongest neophobia. Most coyotes that exhibited neophobia toward a visual stimulus eventually contacted it after varying degrees of investigatory response, but about one-third of them never approached close enough to actually contact the largest stimuli. These individuals, of course, would have avoided a capture device.

My study showed stronger neophobia by coyotes toward the small and medium-sized visual stimuli in the familiar enclosure than in the unfamiliar enclosure. But neophobic responses toward the largest stimuli were equally strong in the familiar and unfamiliar enclosures. In contrast, Harris (1983) reported that a relatively low proportion of coyotes had neophobic interactions with visual stimuli of similar size (15 cm/side) in unfamiliar enclosures. Consequently, he demonstrated significantly greater neophobia by coyotes toward large stimuli in familiar than in unfamiliar enclosures.

Under enclosure conditions, I found distinctly different coyote responses to the two categories of olfactory stimuli tested. The high response rates to FAS and W-U lure by coyotes in both familiar and unfamiliar enclosures support their utility as attractants in both settings. Poor rates of response to coyote urine and liquefied feces during the study may have resulted from either (*i*) the presence of odors from urine and feces deposited in the enclosures by preceding coyotes, (*ii*) relatively weak cues emitted by the substances, or (*iii*) disinterest in the cues that was related to other factors. The greater frequency of responses to urine odor by coyotes in unfamiliar enclosures suggests that they were more attentive to such olfactory cues during exploratory activities in the novel enclosure. Greater overall sensory attentiveness by coyotes in unfamiliar enclosures was also revealed by a higher response rate to the smallest visual stimuli there. The greater exploratory activity by coyotes in unfamiliar enclosures ensured a greater frequency of response to the weaker stimuli. Nevertheless, the trend toward a lower rate of detection of the weaker visual and olfactory stimuli in familiar enclosures suggests that weak stimuli may normally be ignored by wild coyotes in familiar areas and, therefore, may be a factor in the lower capture rates of individuals within their ranges (Windberg and Knowlton 1990).

The relatively weaker neophobic responses by coyotes to scent stations than to novel objects reported by Harris (1983) were probably influenced by the strength of attraction of the olfactory stimulus (FAS) in the stations. Because I observed no neophobia by coyotes toward FAS in this study, I infer that the visual component of scent stations (a 1-m circle of disturbed soil) was the stimulus for the neophobic responses observed by Harris (1983). However, the visual stimulus component of scent stations is also attractive to some individuals, because Roughton and Sweeny (1982) and Turkowski et al. (1983) reported that a substantial percentage of stations (10 and 14%, respectively) prepared without an olfactory attractant (experimental controls) were visited by coyotes.

My observations of the secondary responses of coyotes to visual stimuli revealed both individual differences among animals and habituation. Coyotes that expressed mild or moderate neophobia during the initial interaction generally displayed no neophobia during the second encounter, which indicated habituation. On the other hand, only half of the coyotes that responded with initial strong neophobia showed a lesser degree of neophobia in their secondary response, whereas the others showed equally strong neophobia, suggesting differences in habituation among individuals. Such behavioral differences may have been related to the undetermined social status of individuals.

Although techniques commonly used for capture of coyotes rely heavily on olfactory attractants, the mean response distance for the 4 olfactory stimuli tested in this study was only 2 m. The small and medium-sized visual stimuli tested were recognized at approximately the same distance as the olfactory stimuli. Similarly, Österholm (1964) reported that foxes detected pieces of meat at a distance of only 2 m. Coyote management techniques could be enhanced by increasing the distance at which stimuli are recognized without producing neophobia.

Lehner et al. (1976) suggested that coyotes can learn to associate certain stimuli with their experience of aversive events. Although the degree of generality of the neophobic responses observed in this study for wild coyotes is unknown, I propose that neophobia would be stronger in free-ranging animals. The captives in my study had only limited negative experiences associated with investigating novelty and, hence, were probably quite unwary.

The use of techniques for surveying, capturing, or otherwise manipulating coyotes should include consideration of their potential for generating neophobia toward novel visual stimuli. Scent stations used for coyote surveys (Bean 1981; Roughton and Sweeny 1982) clearly present visual stimuli that can evoke neophobia in some individuals (Harris 1983). In numerous field tests of olfactory attractants, the lures have been presented in scent stations (Fagre et al. 1983; Turkowski et al. 1983; Ebbert and Fagre 1987), which may have altered coyotes' responses. Presentation of capture devices that include a large visual component has the potential to evoke neophobia, and hence cause some coyotes to avoid them. The results of my study suggest that even a relatively small visual stimulus (16–64 cm^2) may evoke relatively more neophobia by coyotes in their familiar areas of activity. Measures to reduce or eliminate visual stimulus components from capture and survey methods offer the potential to improve capture success and reduce bias.

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References

Althoff, D.P. 1978. Social and spatial relationships of coyote families and neighboring coyotes. M.Sc. thesis, University of Nebraska, Lincoln.

Andelt, W.F., Harris, C.E., and Knowlton, F.F. 1985. Prior trap experience might bias coyote response to scent stations. Southwest. Nat. **30**: 317–318.

Bean, J.R. 1981. Indices of predator abundance in the western United States, 1981. U.S. Fish and Wildlife Service, Denver Wildlife Research Center, Denver, Colo.

Ebbert, S.M., and Fagre, D.B. 1987. Importance of attractant qualities for improving a new coyote delivery system. *In* Proceedings of the 8th Great Plains Wildlife Damage Control Workshop, Rapid City, S.D., April 26–29, 1987. *Edited by* D.W. Uresk, G.L. Schenbeck, and R. Cefkin. U.S. Forest Service, Fort Collins, Colo. pp. 189–194.

Fagre, D.B., Howard, W.E., Barnum, D.A., Teranishi, R., Schultz, T.H., and Stern, D.J. 1983. Criteria for the development of coyote lures. *In* Vertebrate pest control and management materials: ASTM STP 817. *Edited by* D.E. Kaukeinen. American Society for Testing and Materials, Philadelphia. pp. 265–277.

Gorman, M.L., and Trowbridge, B.J. 1989. The role of odor in the social lives of carnivores. *In* Carnivore behavior, ecology, and evolution. *Edited by* J.L Gittleman. Cornell University Press, Ithaca, New York. pp. 57–88.

Griffith, D.B. 1976. Seasonal properties of the coyote scent station index. M.Sc. thesis, Oregon State University, Corvallis.

Harris, C.E. 1983. Differential behavior of coyotes with regard to home range limits. Ph.D. thesis, Utah State University, Logan.

Hibler, S.J. 1977. Coyote movement patterns with emphasis on home range characteristics. M.Sc. thesis, Utah State University, Logan.

Kleiman, D.G., and Brady, C.A. 1978. Coyote behavior in the context of recent canid research: problems and perspectives. *In* Coyotes: biology, behavior, and management. *Edited by* M. Bekoff. Academic Press, New York. pp. 163–188.

Lehner, P.N., Krumm, R., and Cringan, A.T. 1976. Tests for olfactory repellents for coyotes and dogs. J. Wildl. Manage. **40**: 145–150.

Linhart, S.B., Roberts, J.D., Shumake, S.A., and Johnson, R. 1976. Avoidance of prey by captive coyotes punished with electric shock. Proc. Vertebr. Pest Conf. **7**: 302–306.

Litvaitis, J.A. 1975. Movements and habitat use of coyotes on the Wichita Mountains National Wildlife Refuge. M.Sc. thesis, University of New Hampshire, Durham.

Macdonald, D.W. 1980. Patterns of scent marking with urine and faeces amongst carnivore communities. Symp. Zool. Soc. Lond. No. 45. pp. 107–139.

Montgomery, K.C. 1955. The relation between fear induced by novel stimulation and exploratory behavior. J. Comp. Physiol. Psychol. **48**: 254–260.

Österholm, H. 1964. The significance of distance receptors in the feeding behaviour of the fox, *Vulpes vulpes* L. Acta Zool. Fenn. **106**: 2–31.

Phillips, R.L., Blom, F.S., and Engeman, R.M. 1990. Responses of captive coyotes to chemical attractants. Proc. Vertebr. Pest Conf. **14**: 285–289.

Roughton, R.D., and Sweeny, M.W. 1982. Refinements in scent-station methodology for assessing trends in carnivore populations. J. Wildl. Manage. **46**: 217–229.

SAS Institute Inc. 1988. SAS/STAT user's guide. Version 6.03. SAS Institute Inc., Cary, N.C.

Turkowski, F.J., Popelka, M.L., and Bullard, R.W. 1983. Efficacy of odor lures and baits for coyotes. Wildl. Soc. Bull. **11**: 136–145.

Windberg, L.A., and Knowlton, F.F. 1990. Relative vulnerability of coyotes to some capture procedures. Wildl. Soc. Bull. **18**: 282–290.

Wells, M.C. 1978. Coyote senses in predation: environmental influences on their relative use. Behav. Proc. **3**: 149–158.

Wells, M.C., and Lehner, P.N. 1978. The relative importance of the distance senses in coyote predatory behaviour. Anim. Behav. **26**: 251–258.

Woodruff, R.A., and Keller, B.L. 1982. Dispersal, daily activity, and home range of coyotes in southeastern Idaho. Northwest Sci. **56**: 199–207.